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OPERATIONS ANALYSIS WORK PAPER NO. 8

W S P A C S

(WEAPON SYSTEM PROGRAMMING AND CONTROL SYSTEM)

MOD ZERO - A DEMONSTRATION MODEL

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OBJECTIVES OF WSPACS: There are two major objectives of WSPACS. First, to provide Air Force management with a broad planning device; secondly, to provide techniques of use to both Air Force and Industry in maintaining control and surveillance over the expenditure of their development and production monies. Although the primary purpose of this presentation is to describe the broad planning aspects of the WSPACS effort, we would nevertheless like to describe very briefly those aspects of WSPACS dealing with control and surveillance, so that you will at least be acquainted with them. While control and surveillance on the one hand and planning on the other are quite different from each other, both in nature and objectives, they have both been encompassed within the WSPACS project, since it is firmly believed that the data generated for one aspect will be similar, if not identical, to that required for the other. The three major elements required for control over expenditures are: (1) an expenditure projection; (2) a record of actual expenditures; and (3) a network depicting in sequential order the things which must be done to bring a weapon system into the inventory. Such networks are used in the Air Force FEP system and in the Navy PERT system for management control over individual weapon systems. It is quite likely, however, that the WSPACS networks, while of the same nature as these, would be much more aggregated and less detailed. Two types of management surveillance as envisioned by WSPACS are depicted in Charts 1 and 2. In Chart 1, the heavy black line represents ^{an} expenditure projection. Since it is a projection, it should be expected that actual expenditures would vary somewhat from the projected expenditures. It is hoped that "control limits" can be developed within which variations from projections can be attributed primarily to chance. Variations exceeding the control limits would be attributed to significant developments and action would then be called for. In Chart 2, the upper portion of the chart again depicts an expenditure projection. The lower portion shows a FEP-type network on the same time scale. A periodic comparison is envisioned to determine whether the total expenditures experienced over time are compatible with the

physical rate of progress on the hardware for which the funds are being expended.

CHART I

Actual vs Projected Expenditures

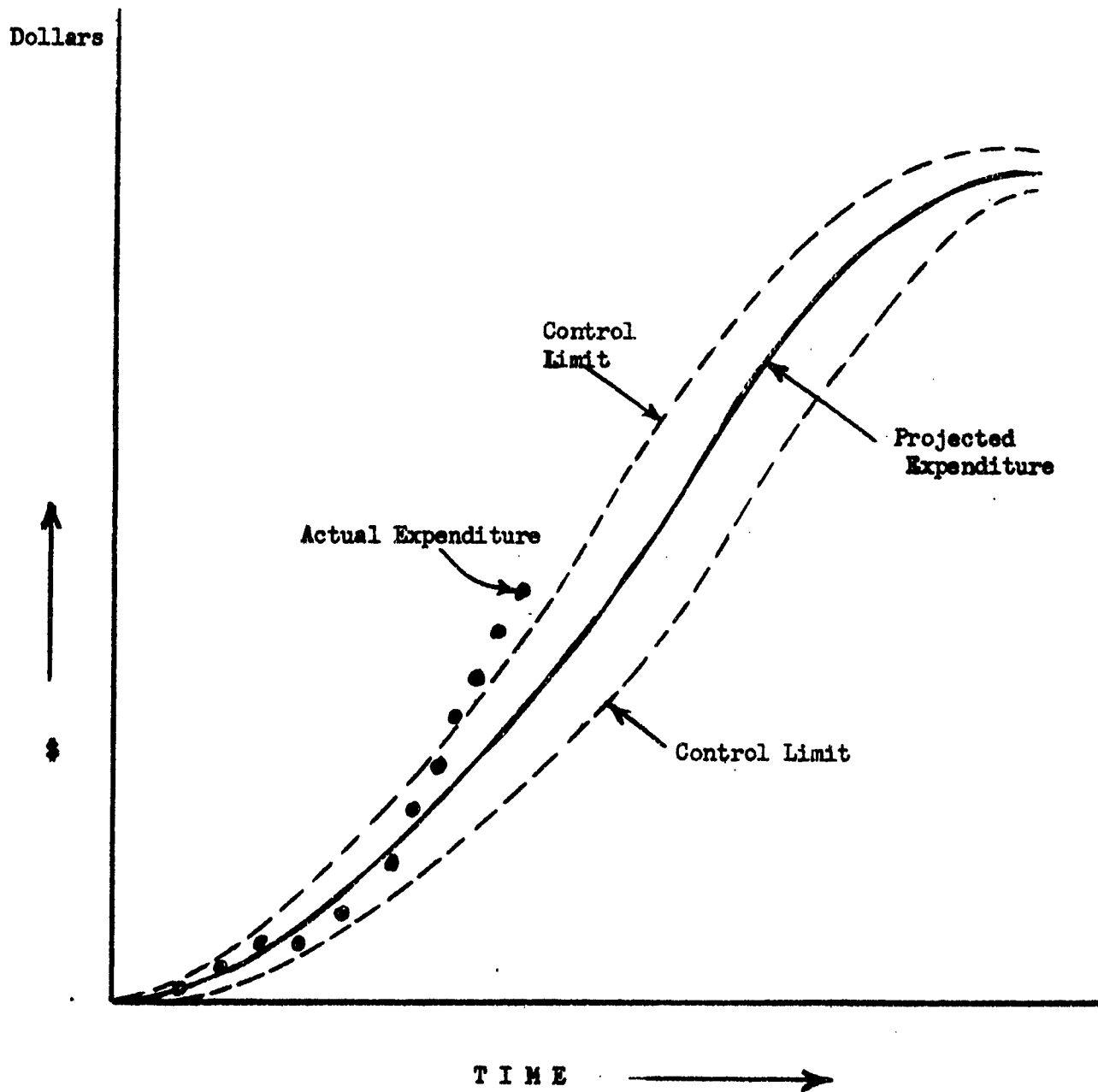
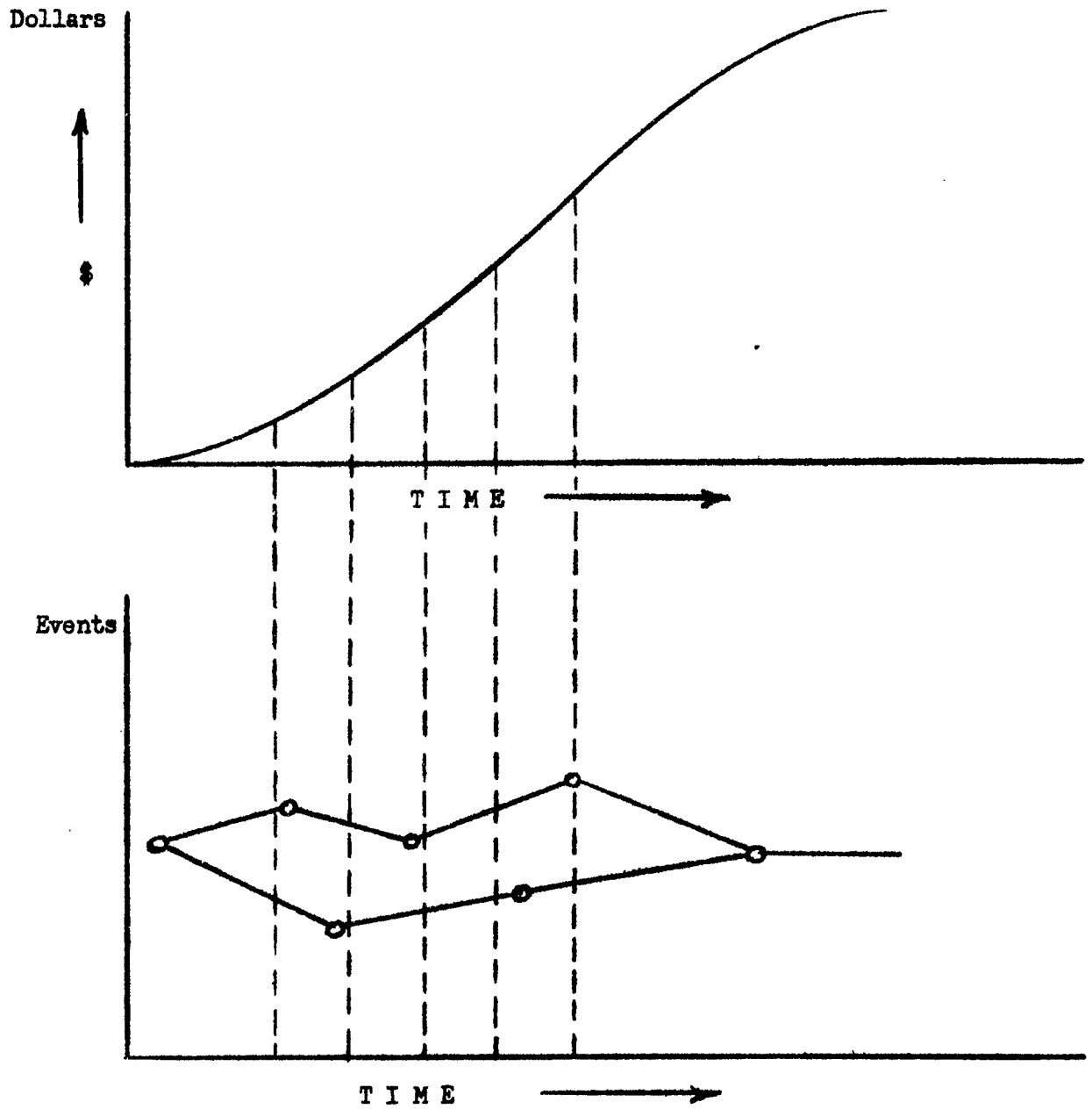


CHART II

Expenditures vs Physical Progress



So much for the control aspect of WSPACS. The planning aspect of WSPACS is oriented toward the problem of reprogramming. It is designed to assist management in evaluating the impact of proposed reprogramming actions, both on the system or systems being reprogrammed, and on the remainder of the Air Force program. In so doing, WSPACS provides assistance to AF management in the allocation of available funds among the various systems comprising the AF force structure.

While there exist, both in the Air Force, in RAND and elsewhere techniques for weapon systems and force structure costing, the novel aspect of WSPACS is its orientation toward reprogramming, that is the measurement of the impact of changes in program.

WSPACS ORGANIZATION: Currently WSPACS is being carried on by a joint AF-Industry effort. The initial goal is admittedly a feasibility determination in which an analysis is being made to ascertain whether there exist mathematical techniques and appropriate data to satisfy the objectives of WSPACS. Industry participation consists of 19 companies which have joined the effort on a voluntary basis on the assumption that the techniques developed will prove of value not only to the Air Force but to Industry as well. Air Force participation is primarily AMC and ARDC.

CHARACTERISTICS OF WSPACS: WSPACS is a man-machine operation. The concept is that a body of data will be stored in a computer. These data will represent the current AF program and, in addition, information which will permit the estimation of development and production costs, system connected costs incurred by the Air Force as a result of introduction of weapons into the inventory, and various other types of pertinent information. When a reprogramming requirement arises, management will input into the computer a reprogramming action which they consider most desirable in the face of the reprogramming requirement. In a relatively short time

the computer will return to management the results of the proposed action. If the solution is infeasible in that it implies expenditures above current or projected limitations, additional suggested solutions may be attempted until one is found which satisfies all financial constraints but, in addition, is compatible with management's judgment with respect to a desirable force structure. In summary, therefore, WSPACS is an iterative process whereby the computer provides management with the results of alternative solutions to reprogramming problems until one is found which is determined to be most desirable within the imposed constraints.

Because of the complexity of the estimations and the requirement for quick response, WSPACS should be considered purely as a broad planning tool in which any estimates provided are only accurate to within "order of magnitude" limits. This is an extremely important point and perhaps should be emphasized. As the planning process proceeds to a more detailed plane, additional and more detailed cost estimates beyond those provided by WSPACS would be necessary. The primary function of WSPACS is to select from the large number of alternative solutions available those which are most likely to be most satisfactory. Additional and more detailed planning is required before final decisions with respect to specific numbers of dollars to be allocated or committed can be made.

As an ultimate goal we would hope that there could be provided some display device so that when proposals for reprogramming actions are placed in the computer the resultant impacts would be almost instantaneously available. This is an objective, however, which will probably be some time in attaining. Initial WSPACE computations are likely to take several hours to complete. Even this, however, represents considerable improvement over currently available techniques.

BASIC WSPACS APPROACH: WSPACS starts with a current program which is stated both in terms of numbers of units and current and projected expenditures. As a result of a reprogramming action, various possibilities can arise. Systems in production may be stretched out, accelerated, or cancelled. Number of vehicles in a system may be increased or decreased. For systems already in the inventory, the phase out may be hastened or delayed. Eventually, though not contemplated in the initial models, operational concepts may be changed, e. g., increasing or decreasing the airborne alert. For each of these types of changes WSPACS estimates the resultant effects on expenditures. WSPACS attempts to estimate not only development and production costs, but also those costs to the Air Force which are associated with the introduction of a weapon system into the inventory. Examples of such system-connected costs are: logistics support, facility construction, training, etc. As programs are changed, the associated system-connected costs are also changed. Thus, WSPACS will demonstrate the fact that production decisions today may have significant impacts in the future in the areas of support, training, and the like. Finally, WSPACS includes an estimate of costs which are not associated with any system but which are, in effect, the overhead of the Air Force. Costs of Headquarters, Air University, Security Service and the like are included in this category. The final product of WSPACS is a total of these projected expenditures compared against known or projected expenditure limitations to determine the feasibility of the reprogramming action.

Ultimately, it is hoped that WSPACS will possess certain optimizing characteristics. For example, if the Air Force program could be stated in terms of a range of units of a weapon system which would be acceptable to the Air Force (as opposed to one specific required quantity) and if the date of final

delivery could be stated as a range of times within which completion of a program is satisfactory (as opposed to a specific date by which final delivery must take place), then the WSPACS solution would select that particular number of units and that particular time of completion which satisfies financial constraints, falls within the specified ranges and minimizes total program costs.

A more desirable optimization would be to maximize the military worth of a force structure for a given budget constraint. While this is admittedly more desirable, it does not appear feasible to introduce this concept explicitly into the model for the foreseeable future. The added complexity which would result thereby, plus the difficulties involved in developing a universally agreed upon set of parameters militate against the immediate inclusion of the military worth concept. It is not believed that WSPACS ignores military worth, however, since it is considered to be provided for in the subjective judgment of management as they manipulate the model. The actions that are taken to accelerate, cancel, phase-out, etc. are done with the intention of arriving at the best possible structure with the funds available.

The number of alternatives which are conceivable in order to meet a reprogramming action is so great that it is not possible to develop a model which will provide for all of them. Consequently, it is the position of those involved in the WSPACS operation that this technique will never be able to answer all questions. It is hoped, however, that it will be able to answer the questions which are most frequently asked and provide for those alternatives which are most frequently used.

DEMONSTRATION MODEL: The remarks which now follow describe a demonstration model of the WSPACS system. The purpose of this model is two fold -- first, to illustrate the objectives of WSPACS in concrete, explicit form; secondly, in view of the fact that the reprogramming problem faced by the Air Force is so complex and is

possessed of so many different facets, additional assurance that WSPACS is oriented in the correct direction is considered extremely desirable. It is believed that placing management personnel into direct contact with the demonstration model will permit them to evaluate our approach in some detail and provide us with necessary guidance.

CHARACTERISTICS OF THE DEMONSTRATION MODEL: In a consideration of this demonstration model it is important that the following characteristics of the model are kept in mind. The model deals with a hypothetical force structure. The numbers of weapons in the structure and the costs reported for them are also hypothetical. Real names have been used for the weapon systems involved only to establish an air of realism, and to preclude the necessity of describing the various systems and the role that they play in a force structure. However, numbers have been purposely changed in order to avoid any security questions and to point out certain principles of WSPACS. Consequently, in considering the model, evaluation should not be made in terms of the validity of the numbers which appear opposite the various systems, but only in terms of the principles demonstrated.

Not only have the numbers themselves been changed but the model itself has been grossly over-simplified in order that it might be quickly programmed and operated on a small-sized computer. The small size computer is a factor here because one is available to the Operations Analysis Office where the demonstration model has been developed. Some of the simplifications that have been built into the model are as follows. The Air Force of the model consists of only eleven weapon systems. The structure includes only missiles and aircraft, excluding such ground systems as SAGE and BMEWS. The development and production costs are only those of the manufacturers' empty weight, excluding such important subsystems

as propulsion, fire control, guidance etc. Missiles have been handled as though they were aircraft, thereby ignoring many of their peculiarities, including training firings. The systems represent only large quantity programs; there are no few-of-a-kind programs such as MIDAS, SAMOS, etc. The system ignores the development test and evaluation phase so that there are no test firings of missiles or test aircraft built. All of these things have been excluded in the demonstration model for various reasons. In many instances WSPACS has just not developed sufficiently to handle them appropriately; in other instances they were excluded in order to fit our model on to our small computer.

Despite all of these omissions, it is believed the demonstration model will, nevertheless, serve its purpose, which is to demonstrate the type of outputs which WSPACS can provide and to obtain from management their reactions as to whether or not WSPACS is oriented toward the real reprogramming problem. Furthermore, despite these omissions, it is believed that the demonstration model will be found to be a reasonable one. For example, the systems in the model will be in various stages of development and production and/or in the inventory. The numbers will move in a reasonable fashion so that rational decisions can be proposed and the model will behave and react in a rational fashion. Many of the costs that have been included are patterned after reality; in fact, in Mod Zero, certain of the parameters used in the cost estimating equations were actually obtained from the producers of these weapons. Consequently, it is believed that the demonstration model will be adequate to fulfill its specified purpose. Obviously, subsequent models, in order to be useful, will have to provide for such omissions and deficiencies as appear in this model. This, of course, is the goal of the WSPACS effort. The purpose of the demonstration model is demonstration only and it is the intention of those concerned with WSPACS that, prior to furnishing the Air Force with a model that

is supposed to be usable, all of the above weaknesses will have been rectified.

The model should also have two other effects. It demonstrates the technical feasibility of developing a mathematical model in which the relevant numbers move in a reasonable, realistic manner. Secondly, it has taught those who worked with it much that will be useful in subsequent development and effort. The demonstration model, although much simplified as compared to the composition of an operational model, is nevertheless a fairly complex model, utilizing the full capacity of the computer on which it was run. Many insights were obtained during the model's construction which will contribute much to future models.

FORCE STRUCTURE: Proceeding now to describe the demonstration model, there is shown in Table I the starting force structure. Note that some of the systems are in the very earliest stages of production; others are well along, and still others are out of production. The time period covered by the model is a 10-year period. There are ballistic missiles, bombers, tankers, fighters and a transport. In this way a number of AF missions are provided for. For example, the missiles, bombers and tankers can be assumed to constitute the strategic force, the fighters may be assumed to constitute the tactical and defense forces, and the transports the supporting forces. Note that not all of the systems are independent of one another. The tanker and the GAM-87 are dependent on the bombers since altering the number of bombers in the force obviously has a direct effect on them. To provide for this relationship in the model we have used an initial bomber to tanker ratio of .4 for the B-52, i. e., two tankers per five B-52's, .5 for the B-58, and .5 for the B-70 (i. e., approximately two bombers per tanker). For the GAM we have used the ratio of 1.2 for the B-52 (i. e., 1.2 GAMs per bomber) and B-58 and 2.2 for the B-70. For each weapon and supporting system, there are displayed the number of

WEAPON SYSTEM UNITS

TABLE I

PROGRAM	Total in Program	Go- Ahead Date	Last Delivery Date	Total Delivered to Date	To be Delivered (FY) (Cum.)									
					1961	62	63	64	65	66	67	68	69	70
ATLAS	276	May 58	Jan 64	8	49	138	230	276	276	276	276	276	276	276
MINUTEMAN	900	Jul 61	Jul 68	0	0	0	0	10	105	368	634	900	900	900
B-70	150	Jul 62	Jul 68	0	0	0	0	0	0	23	83	150	150	150
B-52	705	Apr 53	Nov 61	454	635	705	705	705	705	675	630	555	465	360
B-58	90	Apr 57	Jul 62	8	43	90	90	90	90	90	90	80	70	60
P-47	1410			1410	1185	960	660	255	0	0	0	0	0	0
KC-135	339	Oct 54	Jul 62	168	253	339	339	339	339	339	339	309	269	209
GAM-87	1203	Jul 62	Jul 69	0	0	0	0	0	25	210	511	872	1203	1203
F-X	200	Jul 60	Jul 64	0	0	0	61	200	200	200	200	200	200	200
F-100	350			350	350	350	300	200	150	75	0	0	0	0
C-130	192	May 56	Jul 64	14	41	87	140	192	192	192	192	192	192	192

units in the program, the go-ahead date and the final delivery date for systems introduced, as well as the number already delivered and those to be delivered. Additionally, in Table 2 there is shown the number of vehicles per squadron, the number of active squadrons, and the phase-in and phase-out schedules for these squadrons.

COSTS: Table 3 shows three types of costs -- development and production costs, system-connected costs, and non-system costs. The derivation of development and production costs is one of the most complex parts of the model. Although simplifying assumptions have been made, the results have certain similarities to real-life cost movements. As mentioned earlier, they reflect parameters which were, in a number of cases, provided us by the weapon contractors. It may be of interest to describe very briefly the basis for developing these costs. The development and production process is divided into five components as shown in Chart 3. Note that basic engineering begins at the "go-ahead" and ends at the start of production. Sustaining engineering begins when basic engineering ends and continues through the entire production phase. Basic tooling starts at a pre-designated time-lag after "go-ahead" and continues to a point midway between the start of manufacturing and the delivery of the first vehicle. Sustaining tooling starts at the beginning of manufacturing and continues through the end of the production phase.

The first step in computing program development and production costs is to develop mathematically a production schedule based on the estimated date of first delivery, the estimated date of final delivery, and the number of units involved. This is done using a curve such as is shown in Chart 4a. The rate of production accelerates to a certain point in accordance with the equation appearing on the

TABLE 2

Squadrons - Projected (End of FY) (Cum.)

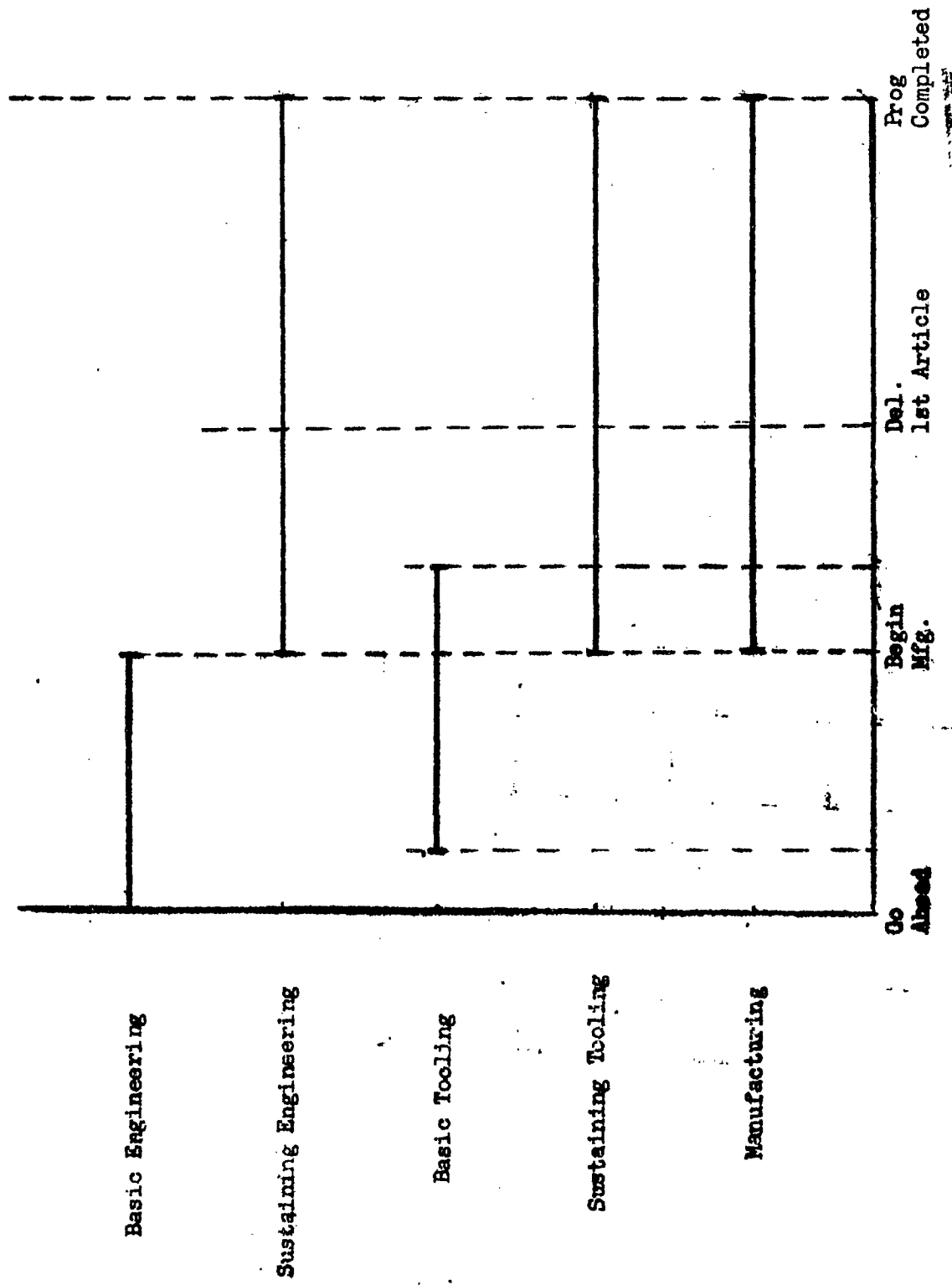
Units Per Squadron	Active Squadrons	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
ATLAS	0	4	11	19	23	23	23	23	23	23	23
MINUTE MAN	50	0	0	0	0	2	7	12	18	18	18
B-70	10	0	0	0	0	0	2	8	15	15	15
B-52	15	42	47	47	47	47	45	42	37	31	24
B-58	10	4	9	9	9	9	9	9	8	7	6
B-47	15	9	64	44	17	0	0	0	0	0	0
KC-135	10	25	34	34	34	34	34	34	31	27	21
GAM-67											
F-104	25	0	0	2	8	8	8	8	8	8	8
F-100	25	14	14	12	8	6	3	0	0	0	0
C-130	16	0	5	8	12	12	12	12	12	12	12

ATLAS AND MINUTEMAN (FY) (Million Dollars) PAGE 3

Type of Expenditure	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	Total
ATLAS											
D and P	65	75	58	16							214
Sys Conn	316	398	367	258	183	183	183	183	183	183	2437
D and P		81	16	74	223	324	304	193			1245
Sys Conn			10	39	102	196	238	282	234	234	1335
MINUTEMAN											
D and P			828	620	453	841	236	137			3115
Sys Conn					4	161	605	1095	1074	1074	4013
B-70											
D and P	95	25									120
Sys Conn	1060	1149	1134	1134	1134	1086	1014	893	748	579	9931
B-52											
D and P	58	25									83
Sys Conn	159	324	309	309	309	309	309	274	240	206	2748
B-47											
D and P	915	741	510	197							2363
KC-135											
D and P	163	87									250
Sys Conn	174	230	230	230	230	230	230	269	181	140	2084
GAM-87											
D and P			64	26	33	95	113	102	72		505
Sys Conn					3	25	62	97	132	127	416
F-104											
D and P	128	179	157	69	64	64	64	64	64	64	533
Sys Conn			17	67							468
F-100											
D and P	126	126	108	72	54	27					513
Sys Conn											
C-133											
D and P	113	108	60	44							325
Sys Conn	19	47	75	112	110	110	110	110	110	110	913
NON-SYSTEM COSTS	1200	1200	1200	1100	1100	1100	1100	1100	1000	1000	
TOTAL EXPENDITURES	4591	4795	5173	4367	4002	4751	4568	4739	4038	3717	
EXPENDITURE LIMITATIONS	4600	4500									

CHART 3

Components of Production



chart, after which it levels off for the remainder of the program. While this is unrealistic, in that the production rate would probably taper off towards the end of production, it was handled as shown because of computer limitations. The value, θ , is the rate of acceleration, and can be thought of as the monthly percentage increase during the acceleration phase. Using this information, a curve of cumulative completions can be drawn, as in Chart 4b. Flow-time learning curves permit the computation of associated starting times, and a starting time curve can then be drawn. This curve also appears in Chart 4b. The horizontal distance between the two curves measures the flow-time at each point along the completion curve. The solid vertical line shown on the chart shows the number of units completed at a point in time. The broken-line extension shows the number of units in process at that same point in time. The assumption was made that half of the in-process units could be taken as "equivalent completions". Application of learning curves for manhours against the total units completed plus "equivalent completions" then provided the manhours required at each point in time for the manufacturing process. These same manhours were used to construct the curve shown in Chart 5, i. e., the percent of total manhours required at each percent of total time.

Total tooling manhours are estimated by use of the following empirical equations:

Total Basic Tooling Manhours

$$= 13K_3 \times 186,000 (100\theta)$$

Total Sustaining Tooling Manhours

$$= (0.558 \times 0.322 \frac{W}{100,000} \times 308 \theta) M_1$$

Where:

- K_3 = Experimental model tooling manhours
- W = AMPR weight in pounds
- M = Total manufacturing manhours
- θ = Rate of acceleration

Chart 4a - Production Rate

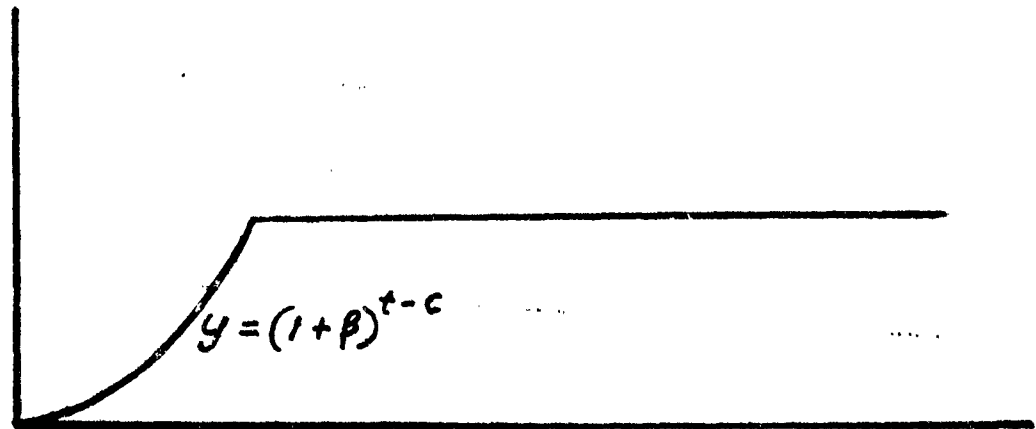


Chart 4b - Cumulative Starts and Completions

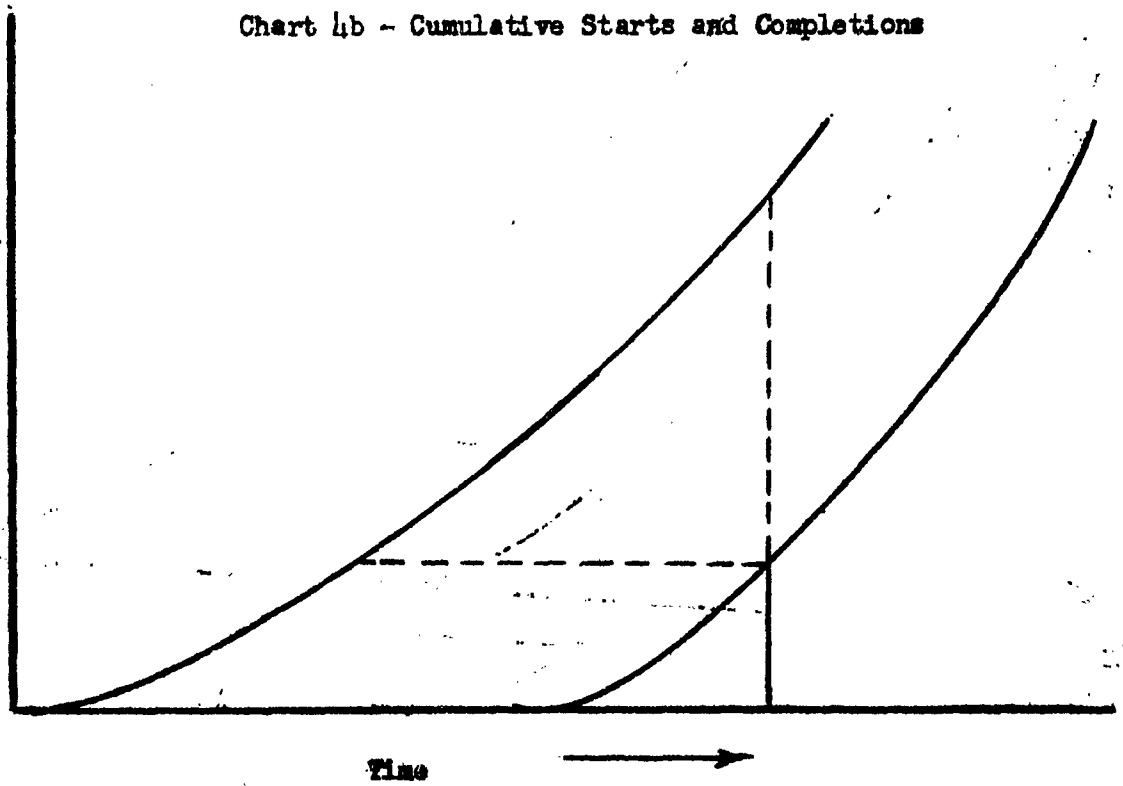
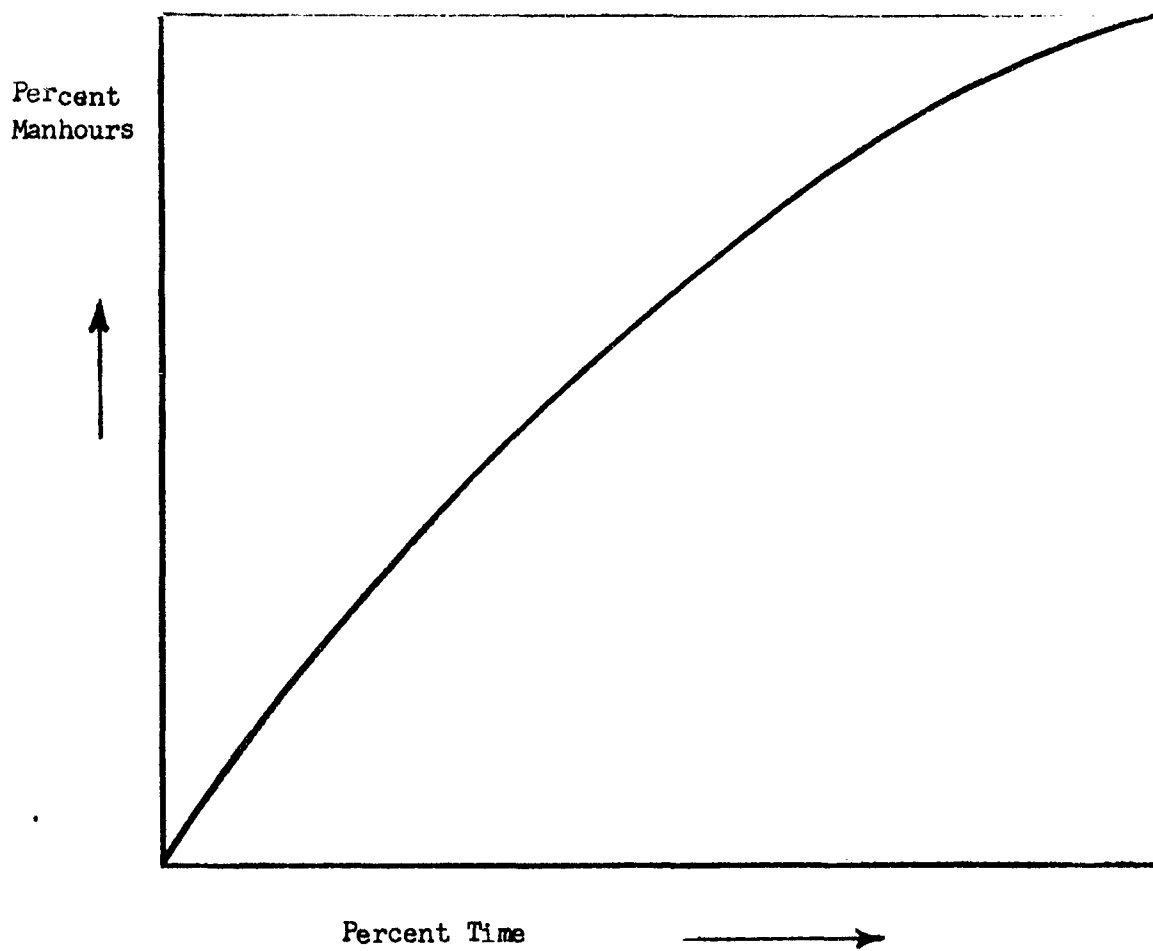


Chart 5 - Percent Time - Percent Manhours



These manhours were spread across time, utilizing the Curve of Chart 5. This assumes that manhours of tooling are distributed in the same way as manufacturing manhours.

Basic and sustaining engineering were computed as a percentage of basic and sustaining tooling, respectively. The ratios were provided by the manufacturers of the weapons concerned. Manhours were spread over time by use of Chart 5, just as was done for tooling.

When changes are called for as a result of changes in go-ahead date, ending date or number of units, these changes are accomplished by mathematical approximations too detailed to go into here. Manhours are then translated into dollars by means of a cost per manhour factor, where the factor includes direct and indirect costs, profits and an inflation factor representing rising price levels, wage levels, etc.

The second type of costs is designated system-connected costs. These costs, in an operational model, would include construction costs, support costs, training costs, modification costs, in short, all the costs that arise as a result of placing a weapon in the inventory. The demonstration model is very gross with respect to these costs. This is a reflection of the fact that an adequate representation of such costs would require a complex model and much more detailed research than could be performed in the time available. While the Rand Corporation has done extensive work in this area, there was not sufficient opportunity to take full advantage of their achievements. It is intended, however, that in the future, careful analysis will be made to determine the degree of applicability of their techniques to WSPACS.

The systems-connected costs reflected in the Demonstration Model purport to cover two categories -- facility construction or modification and logistics

support. Construction costs have been handled in the following manner:

a. Ballistic Missiles: It was assumed that there existed a three-year lead time for missile sites and a requirement to build new sites for each new squadron activated. Cost per squadron was set at \$47 million for the Atlas and \$20 million for the Minuteman. Facility costs for the GAM-87 were set at \$15,000 per GAM. Funds were expended at the rate of 25% the first year, 35% the second year and 40% the third year.

b. Aircraft: It was assumed that no new aircraft bases would be built, but that facility modification would be required for each new squadron activated. The modification costs used were \$5,000,000 per squadron for the B-70, B-52 and B-58; \$500,000 for the fighters and the C-133. A two-year lead time was used with funds expended at the rate of 60% the first year and 40% the second year.

Support costs consisted of operators and maintenance expenditures, to which were added the costs of military personnel. The former was computed in such a way as to be proportional to the unit cost of the weapon system; the latter was based on an average annual salary and the average number of personnel per squadron. Annual support costs used were: (Per Squadron)

Atlas - \$7,900,000	B-58 - \$34,300,000
Minuteman - \$13,000,000	B-47 - \$11,180,000
B-70 - \$71,600,000	F-X - \$ 9,025,000
B-52 - \$24,135,000	F-100 - \$8,970,000
KC-135 - \$6,970,000	GAM-87 - \$106,000/GAM

The third type of cost is the non-system cost. This is the AF overhead which carries on independently of the systems phased in or phased out, e. g., AF Headquarters, Air University, Security Services, etc. This type of cost varies relatively little from year to year and in the demonstration model is

approximately the same percentage of total costs as is the case for the real AF budget.

OPERATING THE MODEL: To operate the model, one starts with a set of data such as those which appear in Tables 1, 2 and 3, representing the current AF program. The moderator then imposes a reprogramming requirement. Any one or more of the following causes for reprogramming are possible and may constitute the situation to be faced.

- a. Reduction in AF expenditure ceilings.
- b. Increase in AF expenditure ceilings.
- c. Communist bloc advances in weaponry, requiring speeding up of one or more weapons.
- d. Technological advances causing obsolescence of one or more systems.

In response to these reprogramming requirements, management may take the following actions:

- a. Cancel weapon systems.
- b. Reduce or increase the number of units in a weapon system. Reductions or increases must be in squadron sizes, however, so that this action in effect decreases or increases the number of squadrons planned.
- c. Stretch out weapon system programs.
- d. Accelerate weapon system programs.
- e. Change "go-ahead" dates.
- f. Speed up or stretch out planned phase-out of squadrons in the inventory.
- g. Change bomber to tanker ratio.
- h. Change bomber to GAM ratio.

If, as a result of any of these actions, the resulting program turns out to be infeasible, in that total expenditures exceed expenditure limitations, management may pose additional solutions to the computer until such time as a solution is found which is both feasible and satisfactory with respect to the military worth of the program.

In the model:

a. A desired acceleration in production quantities or times will not take effect for a period of some months, representing the lead time required for such changes to be instituted.

b. Cancellation of a weapon system will generate termination costs; cut backs will generate penalty costs.

c. Acceleration will increase total costs; deceleration will reduce the near-future expenditures, but may increase total costs.

d. Squadron phase-in is a function of the production schedule. Since the schedule is computed mathematically from "go-ahead", final delivery date and number of units, rate of phase-in can be changed only by changing the period between "go-ahead" and final delivery.

e. Tankers and GAMs are partly "captive" items, i. e., no decisions are made on the number required; decisions which are made on the bombers automatically determine the number of tankers and GAMs required. Decisions can be made, however, on the bomber-tanker and bomber-GAM ratios and on their final delivery dates.

f. Maximum monthly production rates permitted are as follows:

Atlas - 20	B-58 - 25
Minuteman - 30	KC-135 - 30
B-70 - 10	GAM-87 - 45
B-52 - 30	F-104 - 35
	C-133 - 10

Any requirement imposed on a system which infers a monthly production rate higher than those shown here will be indicated as infeasible.

MODEL PLAY: On 29 November 1960, a demonstration of the model was presented to a group of AMC and ARDC personnel whose official interests are in the programming and reprogramming area. The current program which was presented to them is depicted by Tables 1, 2 and 3^{1/}. The reprogramming requirement which was imposed was a reduction in the FY 61 expenditure limitation to \$4.4 billion; at the same time, it was stated that intelligence with respect to enemy capability indicated that it would be extremely desirable to speed up our missile program to the greatest possible extent.

The group took the following actions in response to this requirement:

- a. Accelerated the Atlas program by advancing the last delivery date from January 1964 to January 1963.
- b. Moved the go-ahead date on the Minuteman from July 1961 to December 1960.
- c. Cancelled the B-58.
- d. Speeded up the phase-out of the B-47 by reducing to 70 squadrons in FY 6 instead of 79 squadrons as originally planned.

The results of these actions as computed by the model are shown in Tables 4, 5 and 6. In summary:

- a. Atlas expenditures increased during the early years. The total program cost rose from \$214 million to \$295 million. While the phase-in was not affected in FY 1961, it was possible to put two more squadrons in place by FY 1962 and be at full strength by FY 1963.

^{1/} See pages and

b. Minuteman expenditures increased during the early years. While the lead times did not permit any phase-in earlier than FY 1965, it was possible to put an additional team in place during that year, and to speed up generally the phase-in process.

c. Cancellation of the B-58 resulted in the completion of 13 aircraft which were in process at the time of termination. Substantial savings in funds occurred.

d. As a result of the B-58 cancellation, a reduction occurred in the quantities of KC-135s and GAMS required. This resulted in immediate savings in the KC-135 area and subsequent savings in the GAM area.

e. The accelerated phase-out of B-47's resulted in additional savings in FY 1961 expenditures.

As a result of these actions, FY 1961 expenditures were projected as coming within the revised expenditure limitation.

DESIRED RESULTS OF DEMONSTRATION:

The model has attempted to generate an environment approximating as closely as possible that which is experienced in real life. As a result of operating the model it is hoped that the model will elicit from management answers to the following questions:

a. Is the information initially presented to management approximately that which is available (or ought to be available) to them when faced with a real life reprogramming problem? What are the deficiencies both in terms of information made available by the model which would not normally be available in a real situation and the converse?

b. Do the reprogramming requirements imposed by the moderator reflect those which occur in real life? Are there additional causes for

WEAPON SYSTEM UNITS

TABLE 4

	Total In Program	Co- Ahead Date	Last Delivery Date	Total Delivered to Date	To be Delivered (FY) (Cum.)									
					1961	62	63	64	65	66	67	68	69	70
SEAGRAM														
ATLAS	276	May 58	Jan 63 <u>Jan 64</u>	8	159	138	276	276	276	276	276	276	276	276
MINUTEMAN	900	Dec 60	Jul 68 <u>Jul 61</u>	0	0	0	0	31	182	421	661	900	900	900
B-70	150	Jul 62	Jul 68	0	0	0	0	0	0	23	83	150	150	150
B-52	705	Apr 53	Nov 51	154	635	705	705	705	705	675	630	555	465	360
B-58	Cancel (90)	Apr 57	Jul 62	8	21	(90)	(90)	(90)	(90)	21	21	21	21	21
B-47	1110			1110	1050									
					(1185)	960	660	255	0	0	0	0	0	0
KC-135	308	Oct 54	Jul 62	168	253	(339)	(339)	(339)	308	308	308	278	238	178
GAM-87	1133	Jul 62	Jul 69	0	0	0	0	0	25	197	509	821	1133	1133
	(1203)				0	0	0	0	(25)	(210)	(541)	(872)	(1203)	(1203)
F-X	200	Jul 60	Jul 64	0	0	0	61	200	200	200	200	200	200	200
F-100	350			350	350	350	300	200	150	75	0	0	0	0
C-130	192	May 58	Jul 68	14	141	87	140	192	192	192	192	192	192	192

TABLE 5
Squadrons - Projected (End of FY) (Cum.)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Units Per Squadron	Active Squadrons									
ATLAS	12	4	13 (11)	23 (23)	23 (23)	23 (23)	23 (23)	23 (23)	23 (23)	23 (23)
MINUTE-MAN	50	0	0	0	3 (2)	8 (7)	13 (12)	18 (18)	18 (18)	18 (18)
B-70	10	0	0	0	0	2	8	15	15	15
B-52	15	42	47	47	47	45	42	37	31	24
B-58	10	2 (4)	2 (9)	2 (9)	2 (9)	2 (9)	2 (9)	2 (8)	2 (7)	2 (6)
B-47	15	70 (79)	64	17	0	0	0	0	0	0
KC-135	10	25	30 (34)	30 (34)	30 (34)	30 (34)	30 (34)	27 (31)	23 (27)	17 (21)
GAM-87										
F-X	25	0	0	8	2	8	8	8	8	8
F-100	25	14	14	8	12	3	0	0	0	0
G-133	16	2	5	12	12	12	12	12	12	12

Type of Expenditure		EXPENDITURES (FY)										TABLE 6		Rev. Tot.
		1963	1964	1965	1966	1967	1968	1969	1970	Total				
ATLAS	D and P	96	143	143	183	183	183	183	183	2437		2462		
	Sys Conn	353	437	371	258	258	258	258	258	1219		1219		
	D and P	316	398	367	285	285	285	285	285	1374		1374		
MINUTEMAN	D and P	38	81	46	103	103	103	103	103	3115		3115		
	Sys Conn	528	620	453	541	541	541	541	541	4013		4013		
	D and P	120	120	120	120	120	120	120	120	120		120		
B-10	D and P	95	25	1134	1086	1014	893	748	579	9931		13		
	Sys Conn	1060	1149	1134	1086	1014	893	748	579	9931		13		
	D and P	1358	925	309	309	309	309	309	309	2748		696		
B-58	D and P	1358	925	309	309	309	309	309	309	2748		696		
	Sys Conn	759	324	309	309	309	309	309	309	2748		696		
	D and P	84	741	510	197	197	197	197	197	2363		196		
B-47	D and P	84	741	510	197	197	197	197	197	2363		196		
	Sys Conn	915	741	510	197	197	197	197	197	2363		196		
	D and P	413	387	309	309	309	309	309	309	2504		1094		
KC-125	D and P	413	387	309	309	309	309	309	309	2504		1094		
	Sys Conn	174	320	309	309	309	309	309	309	2504		452		
	D and P	174	320	309	309	309	309	309	309	2504		452		
GAM-87	D and P	174	320	309	309	309	309	309	309	2504		452		
	Sys Conn	174	320	309	309	309	309	309	309	2504		452		
	D and P	128	179	157	69	69	69	69	69	533		533		
F-104	D and P	128	179	157	69	69	69	69	69	533		533		
	Sys Conn	128	179	157	69	69	69	69	69	533		533		
	D and P	126	126	108	72	72	72	72	72	513		513		
F-100	D and P	126	126	108	72	72	72	72	72	513		513		
	Sys Conn	126	126	108	72	72	72	72	72	513		513		
	D and P	113	108	60	44	44	44	44	44	325		325		
C-135	D and P	113	108	60	44	44	44	44	44	325		325		
	Sys Conn	19	47	75	112	112	112	112	112	913		913		
	NON-SYSTEM COSTS	1200	1200	1200	1100	1100	1100	1000	1000					
TOTAL EXPENDITURES		4395	4560	4908	4058	4268	4473	3835	3551					
		4591	4795	5173	4367	4002	4751	4038	3717					
		4400	4400	4400	4400	4400	4400	4400	4400					
EXPENDITURE LIMITATIONS		4400	4400	4400	4400	4400	4400	4400	4400					

reprogramming which might require actions significantly different from those covered by the model?

c. Are the possible actions available to management realistic?

Are there actions which might be taken other than those available in the model?

d. Are there any other aspects of the model which are unrealistic or which fail to grapple with the real-life reprogramming action?

e. Does the WSPACS technique, as demonstrated by Mod Zero, promise to provide a useful planning device, bearing in mind the fact that the estimates provided can never achieve the precision of detailed cost estimation?

FUTURE WORK TO BE DONE: Assuming that the answer to the last question is in the affirmative, the following tasks remain to be accomplished:

a. Additional conceptual work on mathematical techniques including optimization.

b. Additional research designed to add subsystems (e. g., propulsion, guidance) to airframe analyses.

c. Additional research designed to evaluate applicability of current analytical approaches to items other than aircraft (e. g., missiles, SAGE, BMEWS).

d. Additional research to develop methods for handling few-of-a-kind vehicles.

e. Additional research to incorporate the cost of the R, D, T and E phases, which are particularly important in missiles and space systems.

f. Additional research to develop improved techniques for handling system-connected costs.

g. Investigation of feasibility and cost of obtaining necessary data.

h. Investigation of probable errors of estimates.

- i. Development of a data flow system.
- j. Investigation of additional facets of the reprogramming problem not hitherto considered by WSPACS, but brought to light as a result of the demonstration model.
- k. Study of advanced concepts which could be added to the model such as including military worth explicitly in the model, maximizing military worth of a force structure, etc.

NOTE: The demonstration model was a result of the efforts of many people. Of particular importance to the development of the model were Mr. Jules Silver, who played a key role in the formulation and programming of the model, Dr. William E. Dickison and Lt. A. F. Veinott of Hq AMC. Much thanks are also due Mr. E. I. Pina of the Boeing Airplane Company who provided much assistance and many valuable insights in the construction of the development and production segment of the model.